USDA
NATURAL RESOURCES
CONSERVATION SERVICE

MARYLAND CONSERVATION
PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

CODE 410
(Reported by No.)

DEFINITION

A structure used to control the grade and head cutting in natural or artificial channels.

PURPOSE

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

1. To control erosion in natural or artificial channels;
2. To stabilize channel grade that may be erosive;
3. To prevent the formation or advance of gullies;
4. To reduce pollution hazard and enhance environmental quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies in areas where:

1. Concentration and flow velocity of water cause erosion;
2. A stable channel grade needs to be established;
3. Control of gully erosion is needed;
4. Safe movement of water to a lower elevation is required;
5. Improvement of off-site water quality is needed.

CONSIDERATIONS

Necessary sediment storage should be considered with structures having extended storage, unless a provision is made for periodic cleanout.

In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

Structures located in areas used for livestock, and in urban areas should be fenced as necessary to protect the structure from vandalism, as well as preventing serious injury to trespassers.

Where conditions preclude or make it difficult to establish vegetative cover, consider using non-vegetative coverings such as gravel, geoweb, gabions, interlocking blocks or other type protection.

Water Quantity

Consideration should be given to the following for water quantity:

1. Effects on volumes and rates of runoff, evaporation, deep percolation, and ground water recharge;
2. Effects of the structure on soil, water, and resulting changes in plant growth and transpiration;

Water Quality

The following items should be considered for

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

water quality:

1. Ability of structure to trap sediment and sediment-attached substances carried by run-off;

2. Effect of structure on the susceptibility of downstream stream banks and streambeds to erosion;

3. Effects of the proposed structure on the movement of dissolved substances to ground water;

4. Effects on the visual quality of downstream water resources.

CRITERIA

Embankment

Class (a) dams that have a product of storage times the effective height of the dam of less than 3,000 and an effective height 35 ft. or less shall meet or exceed the requirements specified in the Maryland conservation practice standard for Pond (Code 378).

Class (a) dams that have a product of storage times the effective height of 3,000 or more, those more than 35 ft. in effective height, and all class (b) and class (c) dams shall meet or exceed the requirements specified in Technical Release No. 60 (TR-60).

The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

When designing pipe drop structures without an emergency spillway, design the embankment with a crown over the spillway such that the embankment heights are greatest directly over the pipe structure.

Capacity of Full Flow Open Structures

Design open weir, toewall, chute, and box inlet drop structures according to the principles set forth in the National Engineering Handbook Series, Part 650, Engineering Field Handbook, and other applicable NRCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 1, less any reduction because of detention storage. If site conditions exceed those shown in Table 1, the minimum design 24-hour storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions upstream or downstream. Provisions must be made to ensure re-entry of bypassed storm flows.

Toe wall drop structures may be used if the vertical drop is 4 ft. or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or as specified in Table 1, less any reduction because of detention storage, whichever is greater. The drop box capacity (attached to a new or existing culvert) must equal or exceed the culvert capacity at design flow.

Capacity of Island-type Structures

If the mechanical spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. For channels with very small drainage areas, the mechanical spillway should carry at least the 2-year, 24-hour storm of the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Tables 1 or 2 for total capacity without overtopping the headwall extensions of the mechanical spillway. Provisions must be made for safe re-entry of bypassed flow as necessary.

Capacity of Side-inlet Drainage Structures

The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevation or lateral channels into deeper open channels are shown in Table 2. If site condition values exceed those shown in Table 2, the 50-year frequency storm shall be used for minimum design of total capacity.

Earth Fill

Material – Take fill material from approved designated borrow areas. It shall be free of roots, stumps, wood, rubbish, stones greater than 6 inches, frozen or other objectionable materials. Fill material for the center of the embankment and cut off trench shall conform to Unified Soil Classification GC, SC, CH, or CL.

Placement – Scarify areas, on which fill is to be placed, prior to placement of fill. Place fill materials in layers a maximum of 8 inches thick (before compaction). Layers are to be continuous over the entire length of the fill. Place the most permeable borrow material in the downstream portions of the embankment.

Compaction – Control the movement of the hauling and spreading equipment over the fill so that the entire surface of each lift is traversed by not less than one tread track of the equipment, or achieve compaction by a minimum of four complete passes of a sheepsfoot, rubber tired or vibratory roller. Fill material shall contain sufficient moisture such that the required degree of compaction will be obtained with the equipment used. The fill material shall contain sufficient moisture so that if formed into a ball it will not crumble yet not is so wet that water can be squeezed out.

Cut Off Trench – Excavate the cutoff trench into impervious material along or parallel to the centerline of the embankment as shown on the plans. The bottom width of the trench shall be governed by the equipment used for excavation, with the minimum width being four feet. The depth shall be at least four feet below existing grade or 50% of the embankment height or as shown on the plan. For embankments less than 4 feet in height the cutoff trench shall be equal or greater than 50% of the embankment height. Excavate the side slopes of the trench at 1:1 or flatter. Compact the backfill with construction equipment, rollers, or hand tampers to assure maximum density and minimum permeability.

Structure Backfill

Backfill adjacent to pipes or structures shall be of the type and quality conforming to that specified for the adjoining fill material. Place the fill in horizontal layers not to exceed four inches in thickness and compacted by hand tampers or other manually directed compaction equipment. The material needs to fill completely all spaces under and adjacent to the pipe. At no time during the backfilling operation shall driven equipment be allowed to operate closer than four feet, measured horizontally, to any part of a structure. Under no circumstances shall equipment be driven over any part of a concrete structure or pipe, unless there is a compacted fill of 24 inches or greater over the structure or pipe.

Anti-seep Collars or Cut-off Walls

Install anti-seep collars or cut-off walls around pipe conduits 6 inches or larger. Place collars or cut-off walls within the normal saturation zone, to increase the seep line along the conduit by a minimum of 15 percent. The anti-seep collars or cut-off walls and their connections to the conduit shall be watertight.

Trash Guards

To prevent clogging of the conduit, install an approved type of trash rack on the riser of drop inlets. Design trash racks with openings no larger than ½ of the barrel conduit diameter, but in no case less than 6 inches. Trash racks that are flush with the inlet opening are not allowed.

Drop inlet pipe spillways may need to have an anti-vortex device as part of the trash rack. An anti-vortex device is not required if weir control is maintained in the riser through all flow stages.

Emergency Spillway

Where earth spillways are used in combination with a pipe spillway, they must be designed to

handle the total capacity flow indicated in Tables 1 and 2, minus any pipe flow, without overtopping the dam.

Materials

Structures installed under this standard shall be constructed of durable material such as concrete, bituminous coated corrugated metal pipe, steel pipe, aluminum pipe, aluminized steel pipe, concrete pipe with rubber gaskets, treated wood, riprap, stone, gabions, or other materials with a life expectancy equal to the planned life of the structure.

Corrugated Metal Pipe and its appurtenances will be galvanized and fully bituminous coated and must meet the requirements of AASHTO Specification M-190 type with watertight coupling bands.

Aluminum Pipe and its appurtenances must meet the requirements of AASHTO Specification M-196 or M-211 with watertight coupling bands or flanges.

Aluminum Coated Steel Pipe and its appurtenances must meet the requirements of AASHTO Specification M-274-79I. Coupling bands must be composed of the same material as the pipe and be watertight.

Reinforced Concrete Pipe must meet the requirements of ASTM specification C-76. Joints must be watertight.

Plastic Pipe Materials – PVC pipe must be PVC 1120 or PVC 1220 conforming to ASTM D-1785 or ASTM D-2241. Corrugated High Density Polyethylene (HDPE) pipe, couplings and fittings must meet the requirements of AASHTO M294 Type S with watertight joints.

Rock - Gravel (aggregates) and rock riprap must meet the requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Sections 901.01 and 901.02 respectively.

Geotextile – Geotextile may be woven or non-woven and must meet the requirements of Maryland Department of Transportation, State Highway Administration Standard specifications for Construction and Materials, Section 921.09, Class SE.

Concrete - Concrete must meet the minimum requirements of Maryland Department of Transportation, State Highway Administration Standard Specifications for Construction and Materials, Section 902, Mix No. 3 (3,500 psi), Type IA cement.

Stabilization

Stabilize all exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction in accordance with the Maryland conservation practice standard for Critical Area Planting (Code 342). Install any special protection materials per manufacturer's instructions.

Table 1. Design criteria for establishing minimum capacity of full-flow open structures, box inlets, chutes, open weirs and toewalls.

Maximum Drainage Area (acres)	Vertical Drop (ft)	Frequency of Minimum Design 24-hour Duration Storm	
		Principal Spillway Capacity (yr)	Total Capacity (yr)
5	≤5	2	10
450	≤5	5	10
900	≤10	10	25

Table 2. Design criteria for establishing minimum capacity of side-inlet or pipe-drop structures.

Maximum Drainage Area (acres)	Frequency of Minimum Design 24-hour Duration Storm
450	10
900	25

SPECIFICATIONS

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Remove all trees, brush, stumps, obstructions, and other objectionable material and disposed of so as not to interfere with the proper functioning of the structure.

Construction operations will be carried out in such a manner that erosion will be controlled and water and air pollution minimized. State and local laws concerning pollution abatement will be followed. Construction plans shall detail erosion and sediment control measures to be employed during the construction process.

OPERATION AND MAINTENANCE

An operation and maintenance program should be established to maintain the design integrity of the structure. It should include as a minimum annual inspection and after each storm event. Other items to be addressed include:

1. Removal of any blockage of trash and debris that could affect flows through the structure;

2. Repair and seed bare or eroded area immediately;

3. Check material used in the structure for deterioration or failure, includes rock used for outlet protection;

4. Apply lime and fertilizer according to soil test;

5. Mow when vegetative growth becomes excessive in accordance with Critical Area Planting standard.

SUPPORTING DATA AND DOCUMENTATION

Field Data and Survey Notes

The following is a list of the minimum data needed:

1. Profile along centerline of embankment structure;

2. Profile along centerline of principal spillway;

3. Profile along centerline of emergency spillway, if applicable;

4. Survey of storage area and/or inlet channel to develop topography and storage volumes;

5. Soil investigation logs and notes where necessary.

Design Data

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see chapter 5 of the EFH, Part 650. The following is a list of the minimum required design data:

1. Determine peak runoff from the contributing drainage area for the required design storm in accordance with Chapter 2, Engineering Field Handbook, Part 650 or by other approved method;

2. Design of spillway(s) by using Engineering Field Handbook (EFH) Chapters 3 and 6, National Engineering Handbook Sections 5, 11, 14 or other appropriate design guidance;

3. Quantities estimate;

4. Drawings should show the following as a minimum, plan view, where applicable: profile along centerline of dam; profile along centerline of emergency spillway; cross section through dam at principal spillway; cross section through emergency spillway; and construction details and soil logs, job class shown on plans;

5. Compute earth fill, if needed;

6. Vegetative plan. This must meet the criteria, specifications, and documentation requirements of the Maryland conservation practice standard for Critical Area Planting, code 342. Show on plan.

Construction Check Data/As-built

Record on survey notepaper, SCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted on plans in red. The following is a list of minimum data needed for As-builts:

1. Documentation of site visits on CPA-6. Include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom;

2. A profile of the top of the dam, a profile and cross section of the emergency spillway, where applicable;

3. A profile along the centerline of the principal spillway or drop structure extending upstream and downstream to adequately show inlet and outlet conditions;

4. Elevations of spillway crests, conduit inlet and outlet, inverts, stilling basin;

5. Strength, slump, air-entrainment, and other necessary information for concrete structure documentation;

6. Notes and measurements to show that any special design features were met;

7. Statement on seeding and fencing;

8. Final quantities and documentation for quantity changes, and materials certification;

9. Sign and date checknotes and plans by someone with appropriate approval authority. Include statement that practice meets or exceeds plans and NRCS practice standards.

REFERENCES

1. American Society for Testing and Materials, *ASTM Standards*, Philadelphia, Pennsylvania;

2. Maryland Department of the Environment, Water Management Administration, *1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control;*

3. Maryland Department of the Environment; *Code of Maryland Regulations; Construction of Non-Tidal Waters and Flood Plains;* www.dsd.state.md.us.

4. Maryland Department of the Environment, Water Management Administration, *Maryland's Guidelines to Waterway Construction*, May 1999;

5. Maryland Department of Transportation, State Highway Administration, *Standard Specifications for Construction Materials,* January, 2001;

6. USDA, Soil Conservation Service, Design Note 6, *Riprap Lined Plunge Pool for Cantilever Outlet*, January, 1986;

7. USDA, Soil Conservation Service, National Engineering Handbook, *Section 4, Hydrology*, March, 1985;

8. USDA, Soil Conservation Service, National Engineering Handbook, *Section 5, Hydraulics*, August, 1956;

9. USDA, Soil Conservation Service, National Engineering Handbook, *Section 11, Drop Spillways*, April, 1968;

10. USDA, Soil Conservation Service, National Engineering Handbook, *Section 14, Chute Spillways*, October, 1977;

11. USDA, Soil Conservation Service, Technical Release Number 55, *Urban Hydrology for Small Watersheds*, 1986;

12. USDA, Soil Conservation Service, Technical Release Number 60, *Earth Dams and Reservoirs*, 1985;

13. U.S. Department of Transportation, Federal Highway Administration, *Hydraulic Engineering Circular No. 5*, Hydraulic Charts for the Selection of Highway Culverts, December 1965;

14. USDA Natural Resources Conservation Service, *National Engineering Handbook*, Part 650;

15. USDA, Natural Resources Conservation Service, *Maryland Field Office Technical Guide, Section IV, Standards and Specifications.*